

FORM PTO-1390 (Modified)
(REV 10-95)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES

705/71862-2/8083

DESIGNATED/ELECTED OFFICE (DO/EO/US)

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.5)

CONCERNING A FILING UNDER 35 U.S.C. 371

09/297606

INTERNATIONAL APPLICATION NO.

INTERNATIONAL FILING DATE

PRIORITY DATE CLAIMED

PCT/SE97/01840

4 November 1997

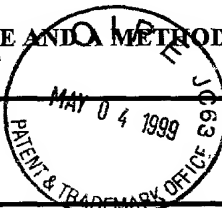
4 November 1996

TITLE OF INVENTION

A STATOR FOR A ROTATING ELECTRIC MACHINE AND A METHOD OF MANUFACTURING A STATOR

APPLICANT(S) FOR DO/EO/US

Bertil LARSSON et al.



Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☐ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
 - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 18 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
A **SECOND** or **SUBSEQUENT** preliminary amendment.
16. ☐ A substitute specification.
17. ☐ A change of power of attorney and/or address letter.
18. ☐ Certificate of Mailing by Express Mail
19. ☒ Other items or information:

WO 98/20595

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.5)

INTERNATIONAL APPLICATION NO.

ATTORNEY'S DOCKET NUMBER

09/297606

PCT/SE97/01840

705/71862-2/8083

20. The following fees are submitted..

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

- ☐ Search Report has been prepared by the EPO or JPO \$840.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) \$670.00
- ☐ No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) \$760.00
- ☒ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$970.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) \$96.00

ENTER APPROPRIATE BASIC FEE AMOUNT =

\$970.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).

\$130.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	55 - 20 =	35	x \$18.00
Independent claims	2 - 3 =	0	x \$78.00

\$630.00

\$0.00

Multiple Dependent Claims (check if applicable). ☐

\$0.00

TOTAL OF ABOVE CALCULATIONS =

\$1,730.00

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). ☐

\$0.00

SUBTOTAL =

\$1,730.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).

\$0.00

TOTAL NATIONAL FEE =

\$1,730.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). ☐

\$0.00

TOTAL FEES ENCLOSED =

\$1,730.00

Amount to be:
refunded

\$

charged

\$

☒ A check in the amount of \$1,730.00 to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **23-0575** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

John P. DeLuca
Watson Cole Grindle Watson
1400 K Street, N.W.
10th Floor
Washington, D.C. 20005-2477

SIGNATURE

John P. DeLuca

NAME

25,505

REGISTRATION NUMBER

May 4, 1999

DATE

09/297606

80 Rec'd PCT/PTO 04 MAY 1999

705/71862-2/8083

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)	PATENT
)	
Bertil LARSSON et al.)	Group: Unknown
)	
Serial No: To be assigned)	Examiner: Unknown
)	
New appln. based on PCT/SE97/01840)	
)	
Filed: On Even Date)	
)	<u>ATTN: BOX PCT</u>
A STATOR FOR A ROTATING ELECTRIC)	
MACHINE AND A METHOD OF)	
MANUFACTURING A STATOR)	

* * * * *

PRELIMINARY AMENDMENT

Washington, D.C.
May 4, 1999

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Concurrently with the U.S. national filing of this application, please amend the present application as follows:

IN THE CLAIMS:

Please cancel claims 21 and 57 without prejudice.

Please amend the claims as follows:

Please delete all multiple dependencies. If any multiple dependencies remain in the claims, it is respectfully requested that said multiple dependencies be deleted and reference be made to the immediately preceding claim.

Please delete all reference numerals in parentheses.

Claim 1 (Amended) A stator for a rotating electric machine for high voltages, comprising a stator, [with] a stator core and a winding, and a rotor, [wherein] said stator core [is provided with] including stator teeth extending radially inwards, towards said rotor[, characterized in that each stator tooth is] configured as a number of tooth sections jointed axially [into] forming a stator tooth plank [and that], a number of said stator tooth planks [are fitted] being fit together side by side [thus] forming a section of a stator core up to [or] a complete stator core, [and] such that when an electric field is generated said field [which] is enclosed within the winding for at least one turn thereof [of the winding].

Claim 2. (Amended) A stator according to claim 1, wherein [characterized in that] a number of [the] said sections [of a stator core] are joined together in order to [achieve] form a complete stator core.

Claim 3. (Amended) A stator according to claim 1, wherein [any one of the preceding claims, characterized in that] said winding [is provided by means of an insulated conductor which] comprises at least one current-carrying conductor, a first layer having semiconducting properties [provided around] surrounding said conductor, a solid insulating layer [provided around] surrounding said first layer, and a second layer having semiconducting properties [provided around] surrounding said insulating layer.

Claim 4. (Amended) A stator according to claim 3, wherein [characterized in that] the stator winding comprises [is provided by means of] a cable[, preferably a high voltage cable].

Claim 5. (Amended) A stator according to claim 3, wherein [any one of claims 3-4, characterized in that said insulated conductor or said] the cable is flexible.

Claim 6. (Amended) A stator according to claim 3, wherein [any one of claims 3-5, characterized in that] at least one of said first layer and said second layer forms an [is arranged to constitute a substantially] equipotential surface surrounding said conductor.

Claim 7. (Amended) A stator according to claim 3, wherein [to any one of claims 3-6, characterized in that] said second layer is [connected] connectable to a predetermined potential.

Claim 8. (Amended) A stator according to claim 7, wherein [characterized in that] said predetermined potential is ground potential.

Claim 9. (Amended) A stator according to claim 3, wherein [any one of claims 3-8, characterized in that] at least two adjacent layers have substantially equal thermal expansion coefficients.

Claim 10. (Amended) A stator according to claim 3, wherein [any one of claims 3-9, characterized in that] each of said three layers is solidly connected to the adjacent layer along substantially the whole of a connecting surface therebetween.

Claim 11. (Amended) A stator according to claim 3, wherein [any one of claims 3-10, characterized in that] said layers [are arranged to] adhere to one another where the [even when the insulated conductor or] cable is subjected to a bending force.

Claim 12. (Amended) A stator according to claim 1, wherein [any one of the preceding claims, characterized in that] the stator winding is insertable [arranged to be inserted] between each stator tooth plank before [they] said planks are [fitted] fit together [to form a section of a stator core or to form a complete stator core].

Claim 13. (Amended) A stator according to claim 1, wherein [any one of the preceding claims, characterized in that] the stator tooth comprises a forward tooth portion facing inwards, towards the rotor, when mounted in the stator, and a yoke portion facing outwards, [that said] each stator tooth [has two] opposite lateral sides each [facing the] confronting a corresponding side of an adjacent stator tooth, [that the] said confronting lateral sides together forming a slot [of the tooth portion facing inwards are provided with slots] for receiving the winding and [that] a lining disposed on at least one of the lateral sides [of the yoke portion is provided with a], the lining being formed [made] of a resilient material.

Claim 14. (Amended) A stator according to claim 1, wherein [any one of the preceding claims, characterized in that] the stator tooth comprises a forward tooth portion facing inwards, towards the rotor, when mounted in the stator and a yoke portion facing outwards, [that said] each stator tooth having a pair of [has two] opposite lateral sides

each lateral side facing [the] a corresponding side of an adjacent stator tooth, [that] the facing lateral sides of the adjacent stator teeth forming [tooth portion facing inwards is provided with] slots for receiving the winding, and [in that it] further comprising [comprises] a separate lining element of a resilient material [which is inserted] located between the facing lateral sides of the yoke portions of [two] adjacent stator teeth.

Claim 15. (Amended) A stator according to claim 1, wherein [any one of the preceding claims, characterized in that] each stator tooth has at least one longitudinal axial notch [is arranged in the tooth,] along its innermost side [and] facing the rotor, and [that] a key element of a non magnetic material is positioned in said notch [in order] to prevent lateral oscillations of said tooth [and/or the adjacent tooth].

Claim 16. (Amended) A stator according to claim 15, further including a lining located in [characterized in that] the notch [is provided with a lining] formed of a resilient material.

Claim 17. (Amended) A stator according to claim 1, further comprising [any one of the preceding claims, characterized in that it comprises] compressing means for

tangentially compressing the teeth [of the stator, thereby] for providing a prestressing at the innermost end of the teeth.

Claim 18. (Amended) A stator according to claim 17, wherein [characterized in that] the compressing means includes a stator frame.

Claim 19. (Amended) A stator according to claim 1, further comprising an annular stator frame surrounding the core for securing [any one of the preceding claims, characterized in that] the stator core sections of the complete stator core [are held] in place [by means of an annular stator frame, surrounding said core].

Claim 20. (Amended) A stator according to claim 18[-19], wherein the tooth has an outer yoke portion, and further including [characterized in that the stator core section is provided with] a stator frame, and a lining of a resilient material located on the external side of the yoke portion of said tooth, [which is] in contact with the stator frame.

Claim 22. (Amended) A stator according to claim 20, wherein [any one of claims 18-21, characterized in that] the stator frame [is provided with] has at least one longitudinal

axial opening and [that] said stator frame includes at least one tightening means for tightening said frame around the stator core by [means of] reducing said opening.

Claim 23. (Amended) A stator according to claim 20, wherein [any one of claims 18-22, characterized in that] the stator frame is divided into at least two frame sections, such that a longitudinal axial opening is formed [created] between the frame sections, and further including [that] means [are provided] for connecting the frame sections and for tightening said frame around the stator core [by means of] for reducing said openings.

Claim 24. (Amended) A stator according to claim 23, wherein [any one of claims 22-23, characterized in that] said means for tightening the stator frame includes a bolted joint operating [and that said bolted joint works] against the [action of the] resilient material of [in] the linings [and/or lining elements].

Claim 25. (Amended) A stator according to claim 24, wherein [any one of claims 22-24, characterized in that] the stator frame further includes a spring[ing] means associated with said tightening means, [and that by means of said springing means the

opening] such that the openings in the stator frame and the winding slots are automatically adjusted to thermal expansions and contractions of the winding.

Claim 26. (Amended) A stator according to claim 25, wherein [characterized in that] the spring[ing] means includes a cup spring.

Claim 27. (Amended) A stator according to claim 17, wherein [any one of claims 17, characterized in that] the compressing means includes a structure of prestressing means, arranged along the circumference of the core, including [and] brackets arranged axially for distributing the compressive force to the core.

Claim 28. (Amended) A stator according to claim 27, wherein [characterized in that] the [prestressing] compressing means includes rods or wires.

Claim 29. (Amended) A stator according to claim 28, wherein [any one of claims 27-28, characterized in that] the each tooth has a yoke portion including an external side and the stator has a yoke for engaging [of] the external side of the yoke portions of the teeth along a contact surface therebetween [are in contact with a stator yoke portion, arranged along said yoke portions], and [that a] friction means is [provided] located at

the contact surface [between said external side of the yoke portions and said stator yoke portion].

Claim 30. (Amended) A stator according to claim 17, wherein [any one of claims 17-28, characterized in that] the compressing means includes at least one clamping ring applied circumferentially around the stator core.

Claim 31. (Amended) A stator according to claim 27 [any one of claims 27-30, characterized in that it] further [comprises] comprising a base upon which the core is supported.

Claim 32. (Amended) A stator according to claim 13, wherein [any one of claims 13-31, characterized in that] the resilient material is rubber.

Claim 33. (Amended) A stator according to claim 1, wherein [any of the preceding claims, characterized in that] each tooth section includes guiding means [and thus each stator tooth plank is provided] on both lateral sides [with]; said guiding means for engaging in mating relation with [designed to fit against] corresponding guiding means [of corresponding shape] on the adjacent stator tooth [planks].

Claim 34. (Amended) A method for [use in the] manufacturing [of] a stator for a high voltage rotating electric machine having [for high voltages, comprising] a stator, with a stator core, [and] a winding and a rotor, wherein said stator core [is provided with] has stator teeth extending radially inwards, towards said rotor[, characterized in:] comprising the steps of:

axially joining a number of tooth sections into a stator tooth plank[, thereby] for forming said stator tooth

fitting, side by side, a number of stator tooth planks, for [thereby] forming [a] at least one section of the [a] stator core [or a complete stator core], and

providing a winding within which a generated electric field is enclosed for at least one turn of said winding.

Claim 35. (Amended) A method according to claim 34, further comprising [characterized in] joining together a number of sections of [a] the stator core [in order to achieve] to form a complete stator core.

Claim 36. (Amended) A method according to claim 34, comprising of [any one of the preceding claims, characterized in] providing a winding comprising a high voltage field confining cable [as described in any one of claims 3-11].

Claim 37. (Amended) A method according to claim 34, comprising the steps of [any one of the preceding claims, characterized in that]

a) removably locating an initial fixture element, [e.g. in the form of] including at least one of a stator tooth plank [or] and a fixture tooth [is removably placed] in a manufacturing fixture

b) removably inserting at least one temporary stator tooth [is removably inserted] in the fixture

c) inserting a stator winding [is inserted] on the temporary stator tooth [or teeth] situated closest to the fixture element

d) removing the temporary stator tooth situated closest to the fixture element [is removed] from the manufacturing fixture, and allowing the stator winding placed on the temporary stator tooth to fall or be pressed down into [and assume its] a correct position in a first winding slot in the fixture element

e) inserting a stator tooth [is inserted] into the manufacturing fixture and fitting the stator tooth [fitted] over the stator winding

f) repeating steps a) through e) [are repeated] until at least a section of [or] a complete stator core has been produced.

Claim 38. (Amended) A method according to claim 37 comprising after step d), gluing a yoke portion of [characterized in that] each stator tooth plank [is glued] to a corresponding yoke portion of a previously fitted stator tooth plank [at its yoke portion after step d)].

Claim 39. (Amended) A method according to claim 37 comprising, gluing [characterized in that] each stator tooth plank [is glued] to a previously fitted tooth plank at a corresponding [its] yoke position after a section of [or] a complete stator core has been manufactured.

Claim 40. (Amended) A method according to claim 37, comprising rotating [any of claims 37-39, characterized in that during manufacture of the stator] the fixture [is rotated] about a horizontal axis corresponding to an axis of [the axial] symmetry [axis] of the stator.

Claim 41. (Amended) A method according to claim 37, comprising joining [any of claims 37-40, characterized in that] the stator windings [are joined] to define [the] an intended number of poles and phases.

Claim 42. (Amended) A method according to claim 34, wherein the stator teeth have lateral side and yoke portion comprising [any one of the preceding claims, characterized in] providing a lining of resilient material to the yoke portion of at least one of two opposite lateral sides of a stator tooth facing the corresponding side of an adjacent stator tooth[, preferably before the fitting].

Claim 43. (Amended) A method according to claim 42, comprising [any one of the preceding claims, characterized in] inserting a lining element of resilient material between the lateral sides of the yoke portions of two adjacent stator teeth,[before or after the fitting]

Claim 44. (Amended) A method according to claim 34, comprising forming notches at a forward end of the stator tooth planks and [any one of the preceding claims, characterized in] inserting key elements of a non magnetic material between the tooth planks, [at the forward end of the teeth facing the rotor,] in the notches [provided for this purpose in the stator tooth planks].

Claim 45. (Amended) A method according to claim 44, comprising of [characterized in] providing a lining of a resilient material inside the notch.

Claim 46. (Amended) A method according to claim 34, comprising [any one of the preceding claims, characterized in] applying compression means for tangentially compressing the teeth of the stator, thereby providing a prestressing at the innermost end of the teeth.

Claim 47. (Amended) A method according to claim 34, wherein the teeth each have an yoke portion and with an external side comprising [any one of the preceding claims, characterized in] providing a lining of a resilient material to the external side of the yoke portion of the stator tooth.

Claim 48. (Amended) A method according to claim 47, wherein the stator has a frame with an inwardly facing surface comprising [any one of the preceding claims, characterized in] providing a lining of a resilient material to the inwardly facing surface of [a] the stator frame, which enters into contact with the external sides of the yoke portions of the stator teeth.

Claim 49. (Amended) A method according to claim 34, comprising [any one of the preceding claims, characterized in] assembling the stator core sections into a complete stator core within a stator frame.

Claim 50. (Amended) A method according to claim 49, wherein adjacent stator planks from slots having walls comprising [any one of claims 47-49, characterized in tightening the stator frame, which constitutes said compression means, and] surrounding the stator core with [whereby the] resilient material, and tightening the stator frame for compressing the resilient material so that [is compressed and] the winding is pressed against the walls of the slots.

Claim 51. (Amended) A method according to claim 34, wherein the teeth each have a yoke portion with an external side and the stator has a yoke engaging the external side at a contact surface, comprising [any one of claims 34-46, characterized in] providing a friction means at the contact surface between the external side of the yoke portions of the teeth and [a] the stator yoke portion arranged circumferentially along said external side of the yoke portions.

Claim 52. (Amended) A method according to claim 46, comprising [any one of claims 46 or 51, characterized in] fitting the core sections together under compression by [means of a structure, which constitutes said compression means,] comprising prestressing [means arranged along] the core about the circumference and [of the core, and brackets arranged axially for] distributing the compressive force to the core.

Claim 53. (Amended) A method according to claim 46, comprising [any one of claims 46-52, characterized in] fitting the core sections together under compression by means of applying at least one clamping ring[, which constitutes said compression means,] circumferentially around the core.

Claim 54. (Amended) A method according to claim 34, comprising [any one of the preceding claims, characterized in] inserting the winding in the axial direction of the stator core.

Claim 55. (Amended) A method according to claim 34, comprising [any one of the preceding claims, characterized in] manufacturing the stator on the site of installation of the rotating electric machine.

Claim 56. (Amended) A stator for a rotating electric machine, [characterized in that it is] manufactured in accordance with the method in claim 34 [any one of claims 34-55].

REMARKS

This Preliminary Amendment is filed for the purpose of conforming the claims to U.S. practice, for deleting multiple dependencies and reference numerals and for adding new claims. Entry and allowance of the claims is earnestly solicited.

Respectfully submitted,



John P. DeLuca
Registration No. 25,505

WATSON COLE GRINDLE WATSON, P.L.L.C.
1400 K Street, N.W., 10th Floor
Washington, D.C. 20005-2477
(202) 628-3600

A stator for a rotating electric machine and a method of
manufacturing a stator

The present invention relates to a stator for a
5 rotating electric machine in accordance with the introductory
part of claim 1, a method for use in the manufacturing a
stator for a rotating electric machine in accordance with the
introductory part of claim 34, as well as a rotating electric
machine in accordance with claim 57.

10 Examples of rotating electric machines which are
relevant in the context of the present invention comprise
synchronous machines, ordinary asynchronous machines, double-
fed machines, applications for asynchronous converter cas-
cades, external pole machines and synchronous flux machines,
15 as well as alternating current machines, which primarily are
intended to be used as generators in power stations for the
generation of electric power.

In the following, mostly synchronous machines are
discussed, but it should be noted that the present invention
20 is not limited to such machines.

Most synchronous machines, according to conventional
prior art, have a field winding in the rotor, where the main
flux is generated by direct current, and an AC winding in the
stator. Stator frames for large synchronous machines are
25 often made of steel sheet with a welded construction. The
laminated core is normally made from enamelled 0.35 or 0.5 mm
electric sheet. For radial ventilation and cooling, the
laminated core, at least for medium-large and large machines,
is divided into stacks with radial ventilation ducts. For
30 larger machines, the sheet is punched into segments, which
are attached to the stator body by means of wedges/dovetails.
The laminated core is retained by pressure fingers and pres-
sure plates. The stator winding is disposed in slots in the
laminated core, which normally have a cross section in the
35 form of a rectangle or a trapezoid.

One major disadvantage with larger stator cores
according to the prior art is the problem of manufacturing

and also transporting such cores. According to convention, the complete stator core, with the frame, is manufactured in a workshop. In order to be able to transport the stator core to the site of installation, the core is then divided into as
5 few core sections as possible, with consideration taken to the transportation facilities. On the site of installation, the core sections are assembled and held together and secured by means of the stator frame, which may comprise several frame sections assembled together. The winding may be in-
10 stalled on the site or partly in the workshop. An alternative, especially for very large sized machines, is to perform more of the manufacturing steps of the stator core on the site of installation, including assembling the punched electric sheets of the core, assembling the core in the stator
15 frame, but not including punching the sheets.

Rotating electric machines have, according to conventional prior art, been designed for voltages in the interval 6-30 kV, where 30 kV normally has been regarded as an upper limit. In the case of a generator, this would normally
20 mean that a generator must be connected to the power network via a transformer, which transforms the voltage up to the level of the power network, which will be in the range of 130-400 kV.

During the years, certain attempts have been made to
25 develop especially synchronous machines, in particular generators, for higher voltages. Examples of this are described in "Electrical World", October 15, 1932, pp 524-525, the article "Water-and-Oil-cooled Turbogenerator TVM-300" in J. Elektrotechnika, No. 1, 1970, pp 6-8, and the patent publica-
30 tions US 4,429,244 and SU 955 369. Unfortunately, none of these have been successful and they have not resulted in any commercially available products.

It appears, however, that it is possible to use high voltage insulated electric conductors with permanent insula-
35 tion, similar to cables used for transmitting electric power (such as XLPE cables), as a stator winding in a rotating electric machine. Thereby, the voltage of the machine may be

increased to such levels that it may be connected directly to the power network, without any intermediate transformer. Such an insulated conductor or cable is flexible and it is of a kind which is described more in detail in the PCT applications SE97/00874 and SE97/00875. Additional descriptions of the concerned insulated conductor or cable can be found in the PCT applications SE97/00901, SE97/00902 and SE97/00903.

From US 5,036,165 is previously known a cable comprising a conductive core surrounded by two semiconducting layers and an intermediate layer of solid insulation. However, this known cable is not intended for use with high voltages and it is, for several reasons, impossible or not suitable to apply in the present invention. Primarily, this is due to the fact that the known cable is of the rigid type, i.e. the layers surrounding the core are reinforced or armoured in such a way that the cable is not flexible and it will not be possible to bend the cable. If an effort is made to bend the cable, ruptures will occur between the layers, which will also be the case if the cable is subjected to thermal expansion.

The object of the present invention is to solve the above mentioned problems and to provide a stator for a rotating electric machine of the above indicated type, which stator is designed in such a way that a new and very flexible manufacturing method will be made possible. The object is also to provide a manufacturing method for a stator as well as a rotating electric machine including the stator.

The object is achieved by means of a stator as described in the introductory part of claim 1, being characterized according to the advantageous features indicated in the characterizing part of said claim. A corresponding method is defined in the characterizing part of claim 34. Finally, the object is also achieved by means of a rotating electric machine in accordance with claim 57, comprising a stator as defined in any one of the claims regarding the stator.

Accordingly, through the feature that each stator tooth is configured with a number of tooth sections joined

axially into a stator tooth plank and that a number of stator tooth planks are fitted together side by side thus forming a section of a stator core or a complete core, is achieved the important advantage that the stator core may be built in

5 sections, where each section may vary from comprising only one tooth plank up to as many tooth planks as is desired from case to case. This means that, if the shape of the complete core may be schematically described as a hollow cylinder, the expression "core section" should be understood to mean a

10 sector of that hollow cylinder. In principle, any section size may be foreseen, determined by manufacturing or transportation aspects. In addition, the feature that an electric field is generated which is enclosed or contained within the winding for at least one turn of the winding has the consid-

15 erable advantage that the electric field will be near zero in the coil-end region outside the winding and that the electric field outside the winding need not be controlled. In other words, the electric field is already controlled in this way. This means that no field concentrations can be obtained,

20 neither within the core, nor in the coil-end region, nor in the transition therebetween.

According to a further advantageous feature, a number of sections of a stator core are joined together in order to achieve a complete stator core. Thus a near complete

25 flexibility is achieved when building stator cores. For example, core sections of any chosen size may be premanufactured and then transported to the installation site of the machine, where the final assembly of the core is made. The sections may be provided with a winding either during the

30 premanufacturing process, in which case the windings of the different core sections will later have to be connected, or on the installation site, in which case preferably the entire winding is installed in one operation. A particular advantage achieved by this is that the transportation is facilitated

35 through not having to transport large stator core sections. This will also have the advantage that it will be possible to

manufacture larger stator cores in general and particularly on the installation site.

The new stator design according to the present invention is particularly advantageous for stators of a large diameter, for in example hydro-generators.

The stator teeth are preferably manufactured from layers of punched electric sheet, which are glued together. The electric sheet in question is preferably an enamelled sheet pasted with some sort of glue or adhesive. A tooth section is made up of a number of layers of electric sheet, generally several hundreds of layers. However, it is also possible that the teeth are made from some other type of material. The tooth sections are then assembled (or stacked) into the so-called tooth plank which constitutes the actual tooth. Preferably the tooth sections are glued together in order to form the plank and any residue of glue in the slots in the tooth sections is eliminated by means of blasting. The metal in the slots is consequently clean, which is advantageous as will be apparent later on.

Another advantage is that the present invention even makes it possible to manufacture the stator core from scratch on the installation site. This is possible since the punched steel sheets making up the tooth sections are so small that it is not impracticable to arrange for a punching machine to produce the sheets on the installation site.

Another important feature of the stator according to the present invention resides in the fact that the winding is provided by means of an insulated conductor which comprises at least one current-carrying conductor, a first layer having semiconducting properties provided around said conductor, a solid insulating layer provided around said first layer, and a second layer having semiconducting properties provided around said insulating layer. Advantageously this insulated conductor is a cable, preferably a high voltage cable.

Through the use of high voltage insulated electric conductors, in the following referred to as high voltage

cables or power cables, with solid insulation of a similar design as previously known cables used for the transmission of electric power (for example so called XLPE cables or cables with rubber insulation), the voltage of the machine may be
5 increased to such levels that it may be directly connected to the power network without passing over a transformer. This leads to the very important advantage that the conventional transformer may be eliminated. Consequently, the solution according to the present invention represents major savings
10 both in economic terms and regarding space requirement and weight for generator plants and other installations comprising rotating electric machines.

To be able to cope with the problems which arise in case of direct connection of rotating electric machines to
15 all types of high-voltage power networks, a machine according to the invention may have a number of features which significantly distinguishes it from the state of the art both as regards conventional mechanical engineering and the mechanical engineering which has been published during the last few
20 years. Some will follow below.

According to a preferred embodiment the insulated conductor or cable is flexible. This feature is important in order to be able to use the cable as a winding. To continue, the first semiconducting layer is substantially at the same
25 potential as the current-carrying conductor. The second semiconducting layer is preferably arranged to constitute a substantially equipotential surface surrounding said conductor and the insulation layer.

The use of a cable with an outer semiconducting
30 layer has the advantage that it permits the outer layer of the winding, in its full length, to be maintained at ground potential. Consequently, the claimed invention may have the feature that the outer semiconducting layer is connected to ground potential. As an alternative, the outer layer may be
35 cut off, at suitable locations along the length of the conductor, and each cut-off part length may be directly connected to ground potential. It is also possible to connect

the outer semiconducting layer to another predetermined potential.

A considerable advantage with having the outer layer connected to ground potential is that the electric field will
5 be near zero in the coil-end region outside the outer semiconductor and that the electric field need not be controlled, as has already been explained.

According to other features at least two adjacent layers have substantially equal thermal expansion coefficients.
10

As a further advantage, each of said three layers, i.e. the two semiconducting layers and the insulation layer, may be solidly connected to the adjacent layer along substantially the whole connecting surface. According to yet another,
15 particularly important feature, said layers are arranged to adhere to one another even when the insulated conductor or cable is subjected to bending.

As yet another advantageous feature the current-carrying conductor/conductors may comprise both non-insulated
20 and insulated strands, stranded into a number of layers. As an alternative, the strands may be transposed into a number of layers. The mixture of both insulated and non-insulated stranded strands or, alternatively, transposed strands entail low additional losses.

Preferably, cables with a circular cross section are
25 used. They have the advantage of bending more easily as well as displaying better electric properties. However, in order to obtain, among other things, better packing density, cables with a different cross section may be used. Finally, it may
30 be mentioned that the cable by preference has a diameter in the interval of 20-250 mm and a conducting area in the interval of 80-3000 mm².

According to one advantageous embodiment the stator is further characterized in that the stator tooth comprises a
35 forward tooth portion facing inwards, towards the rotor, when mounted in the stator, and a yoke (rear) portion facing outwards, that said stator tooth has two opposite lateral

sides each facing the corresponding side of an adjacent stator tooth, that the lateral sides of the tooth portion facing inwards are provided with slots for the winding and that at least one of the lateral sides of the yoke portion is
5 provided with a lining made of a resilient material.

To provide the side of the yoke portion of the stator tooth with a lining made of a resilient material has the considerable advantage that it facilitates the application of the winding in the winding slots. Since, by means of
10 the resilient material, there will occur a certain play between the sides of two adjacent tooth planks the slot openings will be larger. This will have the advantageous result that more space will be available for the winding and the insertion of the winding is facilitated.

15 As an alternative the lining may be replaced by a separate lining element of a resilient material which is inserted between the lateral sides of the yoke portions of two adjacent stator teeth.

According to a preferred embodiment of the invention, the stator is characterized in that it comprises compressing means for tangentially compressing the teeth of the stator, thereby providing a prestressing at the innermost end of the teeth. This feature provides the advantage of providing additional mechanical stiffness and preventing vibrations
20 due to oscillations of the teeth.

According to another advantageous feature, the stator is characterized in that at least one longitudinal axial notch is arranged in the tooth plank, along its innermost side and facing the rotor, and that a key element of a
30 non magnetic material is positioned in said notch in order to prevent lateral oscillations of said tooth plank and/or the adjacent tooth plank. The risk for lateral oscillations of the tooth planks is mainly due to their length and this risk may be eliminated by means of said key elements which are
35 prestressed by the compression means. The key elements should be stiff in order to permit the above mentioned prestressing of the innermost end of the teeth. In a variant, the notch

may be provided with a lining of a resilient material, such as rubber. The purpose of this is to match the stiffness of the innermost end of the teeth with the stiffness in the yoke portion of the teeth/core, in order to obtain an even load distribution and thereby a uniform prestressing of the different parts of the teeth. It may also have certain advantages regarding the ability to absorb thermal movements, as is described below.

According to a first embodiment the compression means are provided by means of a stator frame surrounding the completed stator core, whereby said frame holds the stator teeth of the core and the core sections in place. As a particularly advantageous feature the frame is provided with at least one longitudinal axial opening and includes at least one means for tightening said frame around the stator core by means of reducing said opening. As an alternative, the stator is characterized in that the stator frame is divided into at least two frame sections, and preferably more than two, that a longitudinal axial opening is created between the frame sections, and that means are provided connecting the frame sections and for tightening said frame around the stator core by means of reducing said openings. The means for connecting the frame sections and for the tightening of the frame is preferably a combined means fulfilling both functions. The number of connection/tightening means is preferably equal to the number of frame sections.

Preferably, said tightening means includes a bolted joint, or equivalent means.

As a further feature, the stator frame includes a springing means associated with said tightening means, and, by means of said springing means, the opening/openings in the stator frame and the winding slots are automatically adjusted to thermal expansions and contractions of the winding. The combined arrangement with the lining and/or the lining elements and the springing means associated with the stator frame has a very advantageous effect. When the tightening means is used to tighten the stator frame around the stator

core, the linings or lining elements are compressed and the cable is brought into contact with the wall of the slot in the stator teeth. When the cable is heated up it will expand and the stator teeth will be pressed apart and the mentioned
5 springing means will be compressed. This has the advantage that the risk of the cable being deformed when it expands inside the slots is avoided since the space available for the cable in the slots will adjust to the cross section of the cable, against the action of the springing means. It is also
10 conceivable that the resilient material, which preferably is rubber, will expand when heated up. When the temperature falls the springing means will then make sure that the stator frame and the core is compressed back to its original state, and consequently also the space available for the cable in
15 the slots will be reduced. This has the advantage that it will be possible to absorb and handle thermal movements in the system in a controlled manner. It also serves to fixate the winding in the slots.

As mentioned rubber is one possible choice for the
20 resilient material, other examples are synthetic rubber, plastics, resinous materials, etc.

According to a second embodiment, the compressing means includes a structure of prestressing means, arranged along the circumference of the core, and brackets arranged
25 axially for distributing the compressive force to the core. Preferably said prestressing means includes rods or wires. This embodiment has the particular advantage that the traditional stator frame may be excluded, and thereby the space required for the stator is reduced. According to a preferred
30 feature, the stator also comprises a base upon which the core is supported. It also has the advantages described above regarding adaptation to thermal movements etc.

According to a third embodiment, the core sections may be held together by means of clamping rings in the form
35 of self-supporting steel bands or hoops similar to the type used for barrels.

It may be noted that, while the first embodiment with the stator frame also contributes to the stability and stiffness of the stator, the compression means according to embodiments two and three more or less exclusively function
5 as prestressing means, and therefore the core must be sufficiently stiff by itself. It may also be possible to combine the third embodiment with the previously mentioned two embodiments.

It is also possible to provide electrical insulation
10 between each tooth in order to avoid contact between one layer of laminations and another in an adjacent tooth.

According to a particularly advantageous feature, each tooth section and thus each stator tooth plank may be provided on both lateral sides with guiding means designed
15 to fit against corresponding guiding means of corresponding shape on adjacent stator tooth planks. This feature will facilitate the assembly of the tooth sections in alignment with each other.

The manufacturing method according to the present
20 invention includes steps corresponding to the described features of the stator, in particular axially joining a number of tooth sections into a stator tooth plank, thereby forming said stator tooth; fitting, side by side, a number of stator tooth planks, thereby forming a section of a stator
25 core or a complete stator core; and providing a winding within which a generated electric field is enclosed or contained for at least one turn of said winding.

As a particular advantage it may be characterized in inserting the winding in the axial direction of the stator
30 core.

According to a particularly advantageous embodiment, the winding is manufactured in a fixture in which the winding can be inserted from the yoke side of the fixture/
stator, into removable, temporary, smooth teeth arranged in
35 the fixture. The permanent teeth are applied one by one in the fixture as the temporary teeth are removed one by one, so that the windings gradually fall down into the slots. The

whole stack is subsequently impregnated. The sections are compressed on site with tangentially applied strips or wires or equivalent means.

The winding can thus be completely finished in the fixture where the slots are open towards the yoke and have smooth sides. Upon assembly the lowermost temporary tooth, which is smooth, is removed. The cables, comprising for instance ten winding parts in a slot (may be more or less), fall or are pressed down about one slot pitch against a support in the fixture. This provides space for insertion of the lowermost proper tooth between the cables and the almost smooth tooth. The same procedure is then repeated for each tooth. Since the temporary teeth define the slots in the fixture these have smooth sides which are open towards the yoke side.

Further features and advantages of the present invention will be apparent from the remaining dependent claims.

As a summary, the present invention has the advantage that it provides a unique and very flexible system with individual stator teeth, in which each stator tooth is manufactured separately and is a separate element. This facilitates the construction of stators by means of core sections, built from any suitable number of teeth. The result is a stator core that is both simple with regard to the manufacturing method and easy to transport and install on the final site of operation. Furthermore, the present invention has the advantage that it may be used both in connection with windings of the conventional type and with windings comprising high voltage cables. However, it is primarily intended for use with high voltage cables, and a typical working area for the invention ranges from 36 kV up to 800 kV, preferably 72,5 kV - 800 kV. Secondarily, it is intended for voltages below 36 kV.

The invention will now be described in detail with reference made to preferred embodiments illustrated in the enclosed drawings, in which:

- Fig. 1 shows a schematic view in perspective of a stator according to the present invention,
- Fig. 2a shows a schematic view in perspective of a first variant of a tooth section according to the present invention,
- Fig. 2b shows a schematic view in perspective of a second variant of a tooth section according to the present invention,
- Fig. 3a shows a schematic view in perspective of a first variant of a tooth plank, comprising tooth sections according to Fig. 2a,
- Fig. 3b shows a schematic view in perspective of a second variant of a tooth plank, comprising tooth sections according to Fig. 2b,
- Fig. 4 shows a schematic front view of a first embodiment of a stator according to the present invention,
- Fig. 5 shows a front view of a detail in the stator in Fig. 4,
- Fig. 6 shows a partial schematic view in perspective of a second embodiment of a stator,
- Fig. 7 shows a section of the stator in Fig. 6,
- Fig. 8 shows a schematic view of a production fixture in accordance with the present invention,
- Fig. 9 shows a schematic view of a part of a third embodiment of a stator manufactured in accordance with the present invention, and
- Fig. 10 shows a schematic cross section view of a cable.

It should be noted that, for corresponding elements in the different figures, the same reference numerals have been used.

Fig. 1 shows a schematic drawing of a stator, and its stator core 1, for a rotating electric machine. The stator core is built from a number of substantially wedge-shaped stator tooth planks 2, constituting stator teeth 3 with a forward tooth portion 4, with slots for the winding, and a yoke portion 5, without slots. Said stator tooth planks

2 have been assembled into the cylindrical shape illustrated in Fig. 1. The stator is further provided with a stator winding 6 located in axially extending slots, radially distributed in the stator, between the teeth. The stator winding 5 is shown in Fig. 1 as radially marked lines representing these radially distributed winding slots with the winding 6. A preferred embodiment of the invention includes a stator provided with a stator winding 6 comprising a high voltage cable located in a space, of what may be described as a 10 bicycle chain shape, configured between each individual stator tooth.

Figs. 2a and 2b illustrate two variants of a substantially wedge-shaped tooth section or partial tooth 7, which form a first building element, said stator tooth plank 15 being assembled of a number of said tooth sections and each tooth section 7 representing a slot pitch where the pitch plane cuts through the centre of the radially distributed slots 8. In a machine, according to the present invention, the ventilation ducts may be formed when the tooth sections 7 20 are assembled into a stator tooth plank 2. When doing this, ventilation ducts and cooling ducts may be achieved by placing spacer elements between the tooth sections 7.

It should be pointed out that by the expression "stator tooth section" is intended an element of a certain 25 thickness. If the stator core is of the type built from laminated electrical sheets, each stator tooth section would comprise a number of layers of laminated electrical sheet, generally several hundreds of layers of electrical sheet. This is necessary in order to provide an element with a 30 sufficient stiffness to allow and withstand the necessary handling according to the invention. Accordingly, an example of a suitable size or thickness of a tooth section, when providing cooling ducts, may be 50-100 mm, while an example of a suitable size of a tooth section determined by transportation 35 limitations may be 100-1000 mm. These sizes would also be feasible for other types of stator core tooth sections, for example made of compacted magnetic powder.

upwards. The illustrated stator includes four core sections 1A, 1B, 1C, 1D.

Between the lateral sides of the yoke portions 5 of the teeth there is provided a lining 13 of a resilient material. The lining 13 may either be a lining of resilient material attached directly on the side of one or both teeth in each pair of adjacent teeth, or it may be a separate lining element inserted between the teeth. The resilient material will provoke a small gap or play between the two adjacent teeth, thereby making the slot 8 openings for the winding 14 larger. Consequently, more space will be available for the winding and the insertion of the winding is facilitated.

A lining 15 of a resilient material may also be provided between the external circumferential side of the yoke portion 5 of the teeth 3 and the stator frame 12 surrounding the teeth. This lining may either be attached to the teeth or the inside of the stator frame.

The stator frame may comprise several frame sections. In the embodiment illustrated in Fig. 4, four frame sections 12A, 12B, 12C, 12D have been schematically suggested. The number of frame sections does not necessarily have to correspond to the number of core sections. Between the frame sections longitudinal axial openings 17 are created. The frame sections are connected, in order to form an annular frame, by a means 18 which also functions as a tightening means and which serves to tighten the frame around the core by reducing said openings. This combined connection and tightening means 18 is preferably a bolted joint.

In the detailed illustration of Fig. 5, the stator frame is provided with an axial opening 17 extending along the entire length of the frame. In order to adjust this opening and thereby press together the teeth 3 and also compress the linings 13, 15, the frame is provided with a tightening means, in the form of a bolted joint 18. When the bolted joint is tightened this occurs against the action of the resilient material in the linings. The tightening of the

joint also results in that the windings 14 are pressed against the walls of the slots 8, which, as the cable in the winding is provided with an outer semiconducting layer, leads to the winding being connected to, for example, ground.

- 5 Associated with the tightening means 18, there is also a springing means 20, by means of which the opening/openings in the stator frame and the winding slots are automatically adjusted to thermal expansions and contractions of the winding. Preferably, this springing means is configured as a cup
10 spring, which is compressed when the winding is subjected to thermal expansion in the slots and expanded when the winding is subjected to thermal contraction. Through this arrangement the winding will continuously be in contact with the walls of the slot, without any risk of being deformed when subjected
15 to thermal expansion since the winding slot will automatically adjust to the cross section of the cable thanks to said spring.

Along the inside of the stator teeth, at the air gap end of the slots, i.e. the internal circumference facing the
20 rotor, the teeth are provided with notches 22, as a prolongation of the slots at the air gap, into which key elements 23 are driven. Only one key element has been illustrated in Fig. 5. These key elements are preferably shaped as wedges but also other designs may be used. The purpose of these keys is
25 to prevent lateral oscillations of the tooth planks and to generally improve the stiffness and stability of the stator core. The wedges are of a non-magnetic material, such as glass fibre reinforced epoxy, plastic etc. and they are prestressed when the frame is tightened or by means of the
30 prestressing structure. The wedges may have a slightly arched shape in order to function as a spring. The notches 22 may be provided with a lining of a resilient material, such as rubber. The purpose of the lining is to maintain the compressive prestresses between adjacent stator teeth when the
35 distance between said stator teeth is changed due to thermal expansion or contraction of the winding.

A second embodiment of a stator according to the invention is represented in Figs. 6 and 7. In this embodiment the traditional stator frame has been excluded. The illustrated stator comprises a stator core 30 built from six core sections 31, 32, 33, 34, of which only four are represented in the figure. Each section is built from a number of stator teeth 35, preferably in the form of tooth planks as described above. However, it should be noted that the radial length of the yoke portion of these teeth may vary, and in this embodiment the stator is provided with a stator yoke 36 externally and circumferentially of the teeth, which has not been the case in the previously described embodiment. Naturally, the provision of a separate stator yoke or not, and the size of the yoke portion of the teeth are choices to be made on a case to case basis. This embodiment would normally require that also the stator yoke is divided into sections.

In order to obtain a sufficient stiffness and stability of the core section with windings, the teeth are tangentially compressed using wedges 44, as described above. Contact between teeth shall also be provided at the yoke (rear) end, either by direct contact or by using a spacer means. There is a smooth contact surface 37 between the yoke end of the teeth and a yoke portion 36 of the core arranged circumferentially along the yoke end of the teeth. The compressive force is given by pre-tension provided by steel rods 40 or wires arranged at the outside of the stator yoke. The compressive force is distributed to the core via axial steel brackets 41, which may be welded to the outside yoke portion of the core. The tension force in the wires 40 is balanced by tangential compressive forces in the wedges 44 between tooth parts at the air gap and at the yoke end of the tooth. The yoke end of the teeth 35 may be glued to the stator yoke 36 for increased load capacity, or for practical reasons such as obtaining teeth and yoke of the stator core in one piece. As an alternative, the surface 37 may be subjected to a suitable surface treatment or some sort of pad or lining may be provided in order to increase friction.

It should be noted that the teeth and stator yoke in this embodiment may be substituted for teeth which incorporate the stator yoke in a yoke portion, such as the teeth illustrated in Fig. 9, with or without guiding means.

5 The core is supported on a steel frame 42 at its base. In Fig. 7 may also be seen a cooling duct 43.

Fig. 8 is intended to illustrate how the stator teeth 47 (in the form of stator tooth planks) may be assembled into a stator core section or a complete stator core,
10 using a stator fixture 45. The stator fixture 45 is arranged, with a curve form corresponding to the finished stator, to include a fixture tooth 46 as an initial fixture element shaped as half a stator tooth plank. A first stator tooth plank 2 may possibly be used to start with as this initial
15 fixture element. Furthermore, the stator fixture 45 is arranged to hold removably inserted temporary stator teeth 47 with the correct pitch during assembly. These teeth are wedge-shaped like the stator teeth planks, but are slimmer in order to leave space for the stator winding 6 between each
20 temporary stator tooth 47.

The stator is manufactured by:

- a) removably inserting at least one of the temporary stator teeth 47 in a fixture 45 corresponding to a section of, or a complete stator core,
- 25 b) inserting the stator winding 6 of at least one winding slot, shown in Fig. 8 as a section through ten parallel winding parts, above the temporary stator tooth 47,
- c) removing the temporary stator tooth 47 from the fixture and allowing the winding in the winding slot to fall down or pressing it down to assume its correct position in a
30 first permanent winding slot in either a fixture tooth 46 or a stator tooth plank 2,
- d) inserting a stator tooth plank 2, fitting it above the first winding slot thus formed and securing it against a
35 previously fitted stator tooth plank 2,
- e) thereafter repeating steps a) through d) until a section of or a complete stator has been assembled.

According to another method of manufacturing the stator, all the temporary stator teeth are placed in the fixture, one after another, with the stator winding inserted after each temporary stator tooth. Assembly is then performed
5 by removing the lowermost of the remaining temporary stator teeth 47 from the fixture and allowing the winding in the slot to fall down, or pressing it down so that it assumes a correct position in an adjacent winding slot in either the fixture tooth 46 or in each subsequent stator tooth plank 2.
10 This is repeated until a section or a complete stator core has been produced. The distance from the fixture tooth/first stator tooth plank to the nearest temporary stator tooth inserted is selected so that a stator tooth plank 2 can be fitted over the first winding slot after the temporary stator
15 tooth has been removed and the winding parts have fallen or been pressed into place. As can be seen from the manufacturing method described above, the stator windings may either be placed in a fixture slot by slot or may be completed in the fixture for the section to be produced. A combination of
20 these two manufacturing methods is also covered by the appended claims. The whole stator may possibly be manufactured by arranging the fixture to rotate half a turn, in which case each new stator tooth plank is secured against the previous one. Irrespective of whether one section or the whole stator
25 is being assembled, each stator tooth plank is joined at its yoke portion 5 by means of gluing and a specially provided pressure joint.

Fig. 9 shows three stator tooth planks 2 combined with the stator winding 6 in the slot therebetween. The first
30 stator tooth plank is removably placed against the intermediate stator winding 6 and against the fixture tooth 46, whereas each subsequent stator tooth plank is fixed to a previous one. If a complete stator is being manufactured as one unit, the last stator tooth plank to be fitted will be
35 inserted after tangential expansion of the stator. The stator is then tightened again. Irrespective of which manufacturing method is used, the finished stator core will be compressed

by some type of compressing means. In Fig. 9 these compressing means are illustrated, according to a third embodiment, as a number of clamping rings or hoops 48 of the type used for barrels. The compressing means may in addition also
5 comprise a conventional stator frame, or the type of steel rod/wire arrangement that has been described above.

The tooth planks 2 illustrated in Fig. 9 are of the type illustrated in Fig. 3b including guiding means. Naturally, they may instead be of the type illustrated in Fig.
10 3a, without any special guiding means. In the same manner may the teeth illustrated in Figs. 4-7, which are of the type without a guiding means as illustrated in Fig. 3a, be exchanged for the type of teeth illustrated in Fig. 3b, with guiding means.

15 Finally, in Fig. 10 is represented a cable which is particularly suitable to be used as a winding in the stator according to the invention. The cable 50 includes at least one current-carrying conductor 51 surrounded by a first semiconducting layer 52. Outside said first layer is provided
20 a layer of solid insulation 53. Surrounding the insulation layer is then provided a second semiconducting layer 54. The current-carrying conductor may include a number of strands 56, of which at least some are insulated from each other. The three layers of the cable, i.e. the two semiconducting layers
25 and the insulation layer, are arranged to adhere to each other even when the cable is bent. The cable is consequently flexible and this property is maintained during the entire life of the cable. The illustrated cable also differs from conventional high voltage cables in that it does not include
30 any outer layer for mechanic protection of the cable, nor does it include any metal shield which normally is provided on such a cable.

The above description of preferred embodiments of the invention is only intended as illustrating examples,
35 without limiting the invention. A number of modifications of the present invention may naturally be conceivable within the scope of the following patent claims. - - - - -

Patent claims

1. A stator for a rotating electric machine for high volt-
ages, comprising a stator, with a stator core and a winding,
5 and a rotor, wherein said stator core is provided with stator
teeth extending radially inwards, towards said rotor, **charac-**
terized in that each stator tooth (3) is configured as a
number of tooth sections (7) joined axially into a stator
tooth plank (2) and that a number of stator tooth planks are
10 fitted together side by side thus forming a section (1A, 1B,
1C, 1D; 31, 32, 33, 34) of a stator core or a complete stator
core, and that an electric field is generated which is en-
closed within the winding (6; 14; 38) for at least one turn
of the winding.
- 15 2. A stator according to claim 1, **characterized** in that a
number of the sections (1A, 1B, 1C, 1D; 31, 32, 33, 34) of a
stator core are joined together in order to achieve a com-
plete stator core.
- 20 3. A stator according to any one of the preceding claims,
characterized in that said winding is provided by means of an
insulated conductor (50) which comprises at least one cur-
rent-carrying conductor (51), a first layer (52) having
25 semiconducting properties provided around said conductor, a
solid insulating layer (53) provided around said first layer,
and a second layer (54) having semiconducting properties
provided around said insulating layer.
- 30 4. A stator according to claim 3, **characterized** in that the
stator winding is provided by means of a cable, preferably a
high voltage cable.
5. A stator according to any one of claims 3-4, **characterized**
35 in that said insulated conductor (50) or said cable is flexi-
ble.

6. A stator according to any one of claims 3-5, **characterized** in that said second layer (54) is arranged to constitute a substantially equipotential surface surrounding said conductor.

5

7. A stator according to any one of claims 3-6, **characterized** in that said second layer (54) is connected to a predetermined potential.

10 8. A stator according to claim 7, **characterized** in that said predetermined potential is ground potential.

9. A stator according to any one of claims 3-8, **characterized** in that at least two adjacent layers have substantially equal
15 thermal expansion coefficients.

10. A stator according to any one of claims 3-9, **characterized** in that each of said three layers (52,53,54) is solidly connected to the adjacent layer along substantially the whole
20 connecting surface.

11. A stator according to any one of claims 3-10, **characterized** in that said layers (52, 53, 54) are arranged to adhere to one another even when the insulated conductor or cable is
25 subjected to a bending force.

12. A stator according to any one of the preceding claims, **characterized** in that the stator winding (6) is arranged to be inserted between each stator tooth plank (2) before they
30 are fitted together to form a section of a stator core or to form a complete stator core.

13. A stator according to any one of the preceding claims, **characterized** in that the stator tooth (3) comprises a forward tooth portion (4) facing inwards, towards the rotor, when mounted in the stator, and a yoke portion (5) facing outwards, that said stator tooth has two opposite lateral
35

sides each facing the corresponding side of an adjacent stator tooth, that the lateral sides of the tooth portion (4) facing inwards are provided with slots (8) for the winding and that at least one of the lateral sides of the yoke portion (5) is provided with a lining (13) made of a resilient material.

14. A stator according to any one of the preceding claims, **characterized** in that the stator tooth comprises a forward tooth portion (4) facing inwards, towards the rotor, when mounted in the stator and a yoke portion (5) facing outwards, that said stator tooth has two opposite lateral sides each facing the corresponding side of an adjacent stator tooth, that the lateral sides of the tooth portion facing inwards is provided with slots (8) for the winding, and in that it further comprises a separate lining element (13) of a resilient material which is inserted between the lateral sides of the yoke portions (5) of two adjacent stator teeth.

15. A stator according to any one of the preceding claims, **characterized** in that at least one longitudinal axial notch (22) is arranged in the tooth (3; 35), along its innermost side and facing the rotor, that a key element (23; 44) of a non magnetic material is positioned in said notch in order to prevent lateral oscillations of said tooth and/or the adjacent tooth.

16. A stator according to claim 15, **characterized** in that the notch (22) is provided with a lining of a resilient material.

17. A stator according to any one of the preceding claims, **characterized** in that it comprises compressing means (12; 40, 41; 48) for tangentially compressing the teeth (3; 35) of the stator, thereby providing a prestressing at the innermost end of the teeth.

18. A stator according to claim 17, **characterized** in that the compressing means includes a stator frame (12).

19. A stator according to any one of the preceding claims,
5 **characterized** in that the stator core sections (1A, 1B, 1C, 1D) of the complete stator core are held in place by means of an annular stator frame (12), surrounding said core.

20. A stator according to claim 18-19, **characterized** in that
10 the stator core section is provided with a lining (15) of a resilient material on the external side of the yoke portion (5) of said tooth (3), which is in contact with the stator frame (12).

15 21. A stator according to any one of claims 18-20, **characterized** in that the stator frame (12) is provided with a lining (15) of a resilient material on its inward facing surface, which is in contact with the external side of the yoke portions (5) of the stator teeth (3).

20 22. A stator according to any one of claims 18-21, **characterized** in that the stator frame (12) is provided with at least one longitudinal axial opening (17) and that said stator frame includes at least one means (18) for tightening said
25 frame around the stator core (1) by means of reducing said opening.

23. A stator according to any one of claims 18-22, **characterized** in that the stator frame is divided into at least two
30 frame sections (12A, 12B, 12C, 12D), that a longitudinal axial opening (17) is created between the frame sections, and that means (18) are provided connecting the frame sections and for tightening said frame around the stator core (1) by means of reducing said openings.

35 24. A stator according to any one of claims 22-23, **characterized** in that said means (17) for tightening the stator

frame includes a bolted joint and that said bolted joint works against the action of the resilient material in the linings (13, 15) and/or lining elements.

5 25. A stator according to any one of claims 22-24, **characterized** in that the stator frame (12) further includes a springing means (20) associated with said tightening means (18), and that by means of said springing means the opening/openings (17) in the stator frame and the winding slots
10 (8) are automatically adjusted to thermal expansions and contractions of the winding.

26. A stator according to claim 25, **characterized** in that the springing means (20) includes a cup spring.

15

27. A stator according to any one of claims 17, **characterized** in that the compressing means includes a structure of prestressing means (40), arranged along the circumference of the core (30), and brackets (41) arranged axially for distributing the compressive force to the core.
20

28. A stator according to claim 27, **characterized** in that the prestressing means includes rods or wires (40).

25 29. A stator according to any one of claims 27-28, **characterized** in that the external side of the yoke portions (5) of the teeth (3) are in contact with a stator yoke portion (36), arranged along said yoke portions, and that a friction means (37) is provided at the contact surface between said external
30 side of the yoke portions and said stator yoke portion.

30. A stator according to any one of claims 17-28, **characterized** in that the compressing means include at least one clamping ring (48) applied circumferentially around the
35 stator core.

31. A stator according to any one of claims 27-30, **characterized** in that it further comprises a base (42) upon which the core is supported.

5 32. A stator according to any one of claims 13-31, **characterized** in that the resilient material is rubber.

33. A stator according to any of the preceding claims, **characterized** in that each tooth section (7) and thus each stator tooth plank (2) is provided on both lateral sides with
10 guiding means (9, 10) designed to fit against corresponding guiding means of corresponding shape on adjacent stator tooth planks (2).

15 34. A method for use in the manufacturing of a stator for a rotating electric machine for high voltages, comprising a stator, with a stator core (1; 30) and a winding (6; 14; 38), and a rotor, wherein said stator core (1; 30) is provided with stator teeth (3; 35) extending radially inwards, towards
20 said rotor, **characterized** in:

- axially joining a number of tooth sections (7) into a stator tooth plank (2), thereby forming said stator tooth (3),
- fitting, side by side, a number of stator tooth planks (2),
25 thereby forming a section (1A, 1B, 1C, 1D; 31, 32, 33, 34) of a stator core or a complete stator core, and
- providing a winding (6; 14; 38) within which a generated electric field is enclosed for at least one turn of said winding.

30

35. A method according to claim 34, **characterized** in joining together a number of sections (1A, 1B, 1C, 1D; 31, 32, 33, 34) of a stator core in order to achieve a complete stator core.

35

36. A method according to any one of the preceding claims, **characterized** in providing a winding as described in any one of claims 3-11.

5 37. A method according to any one of the preceding claims, **characterized** in that

- a) an initial fixture element, e.g. in the form of a stator tooth plank (2) or a fixture tooth (46) is removably placed in a manufacturing fixture (45),
- 10 b) at least one temporary stator tooth (47) is removably inserted in the fixture (45),
- c) a stator winding (6) is inserted on the temporary stator tooth or teeth (47) situated closest to fixture element (2, 46)
- 15 d) the temporary stator tooth (47) situated closest to the fixture element (2, 46) is removed from the manufacturing fixture (45), allowing the stator winding (6) placed on the temporary stator tooth (47) to fall or be pressed down and assume its correct position in a first winding slot in
- 20 the fixture element (2, 46),
- e) a stator tooth (3) is inserted into the manufacturing fixture (45) and fitted over the stator winding (6),
- f) steps a) through e) are repeated until a section of or a complete stator core has been produced.

25

38. A method according to claim 37, **characterized** in that each stator tooth plank (2) is glued to a previously fitted stator tooth plank (2) at its yoke portion (5) after step d).

30

39. A method according to claim 37, **characterized** in that each stator tooth plank (2) is glued to a previously fitted tooth plank (2) at its yoke portion (5) after a section of or a complete stator core has been manufactured.

35

40. A method according to any of claims 37-39, **characterized** in that during manufacture of the stator the fixture (45) is

rotated about a horizontal axis corresponding to the axial symmetry axis of the stator.

41. A method according to any of claims 37-40, **characterized** in that the stator windings (6) are joined to define the intended number of poles and phases.

42. A method according to any one of the preceding claims, **characterized** in providing a lining (13) of resilient material to the yoke portion (5) of at least one of two opposite lateral sides of a stator tooth (3) facing the corresponding side of an adjacent stator tooth, preferably before the fitting.

43. A method according to any one of the preceding claims, **characterized** in inserting a lining element (13) of resilient material between the lateral sides of the yoke portions (5) of two adjacent stator teeth (3), before or after the fitting.

44. A method according to any one of the preceding claims, **characterized** in inserting key elements (23; 44) of a non magnetic material between the tooth planks (2), at the forward end of the teeth (3; 35) facing the rotor, in notches (22) provided for this purpose in the stator tooth planks.

45. A method according to claim 44, **characterized** in providing a lining of a resilient material inside the notch.

46. A method according to any one of the preceding claims, **characterized** in applying compression means (12; 40,41; 48) for tangentially compressing the teeth (3; 35) of the stator, thereby providing a prestressing at the innermost end of the teeth.

47. A method according to any one of the preceding claims, **characterized** in providing a lining of a resilient material

(15) to the external side of the yoke portion (5) of the stator tooth.

48. A method according to any one of the preceding claims,
5 **characterized** in providing a lining of a resilient material (15) to the inwardly facing surface of a stator frame (12), which enters into contact with the external sides of the yoke portions (5) of the stator teeth (3).

10 49. A method according to any one of the preceding claims, **characterized** in assembling the stator core sections (1A, 1B, 1C, 1D) into a complete stator core within a stator frame.

50. A method according to any one of claims 47-49, **character-**
15 **ized** in tightening the stator frame (12), which constitutes said compression means, and surrounding the stator core whereby the resilient material (13, 15) is compressed and the winding (14) is pressed against the walls of the slots (8).

20 51. A method according to any one of claims 34-46, **character-**
ized in providing a friction means (37) at the contact surface between the external side of the yoke portions of the teeth (35) and a stator yoke portion (36) arranged circumferentially along said external side of the yoke portions.

25 52. A method according to any one of claims 46 or 51, **character-**
terized in fitting the core sections together under compression by means of a structure, which constitutes said compression means, comprising prestressing means (40), arranged
30 along the circumference of the core (30), and brackets (41) arranged axially for distributing the compressive force to the core.

53. A method according to any one of claims 46-52, **character-**
35 **ized** in fitting the core sections together under compression by means of applying at least one clamping ring (48), which

constitutes said compression means, circumferentially around the core.

54. A method according to any one of the preceding claims,
5 **characterized** in inserting the winding (6; 14; 38) in the axial direction of the stator core.

55. A method according to any one of the preceding claims,
characterized in manufacturing the stator on the site of
10 installation of the rotating electric machine.

56. A stator for a rotating electric machine, **characterized**
in that it is manufactured in accordance with the method in
any one of claims 34-55.

15

57. A rotating electric machine for high voltages, including
a rotor and a stator according to any one of claims 1-33, or
56.

- - - - -

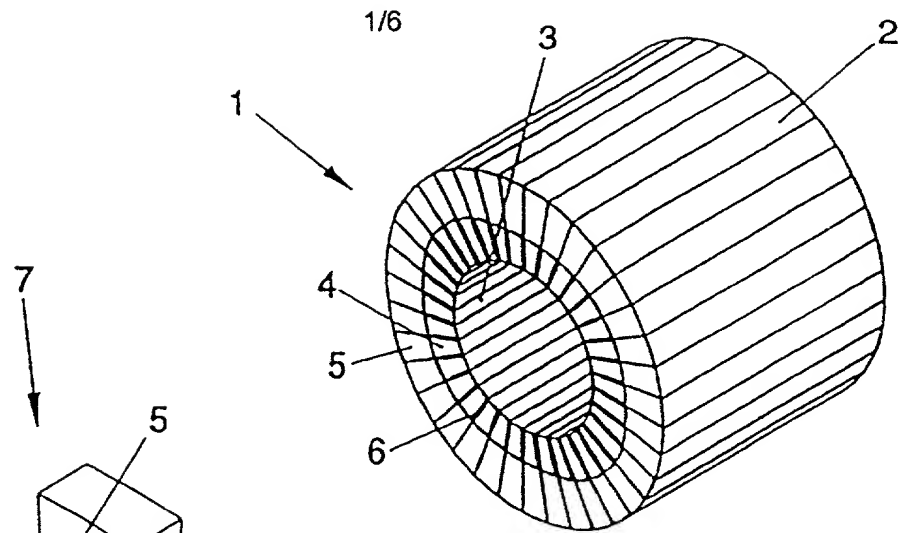


Fig. 1

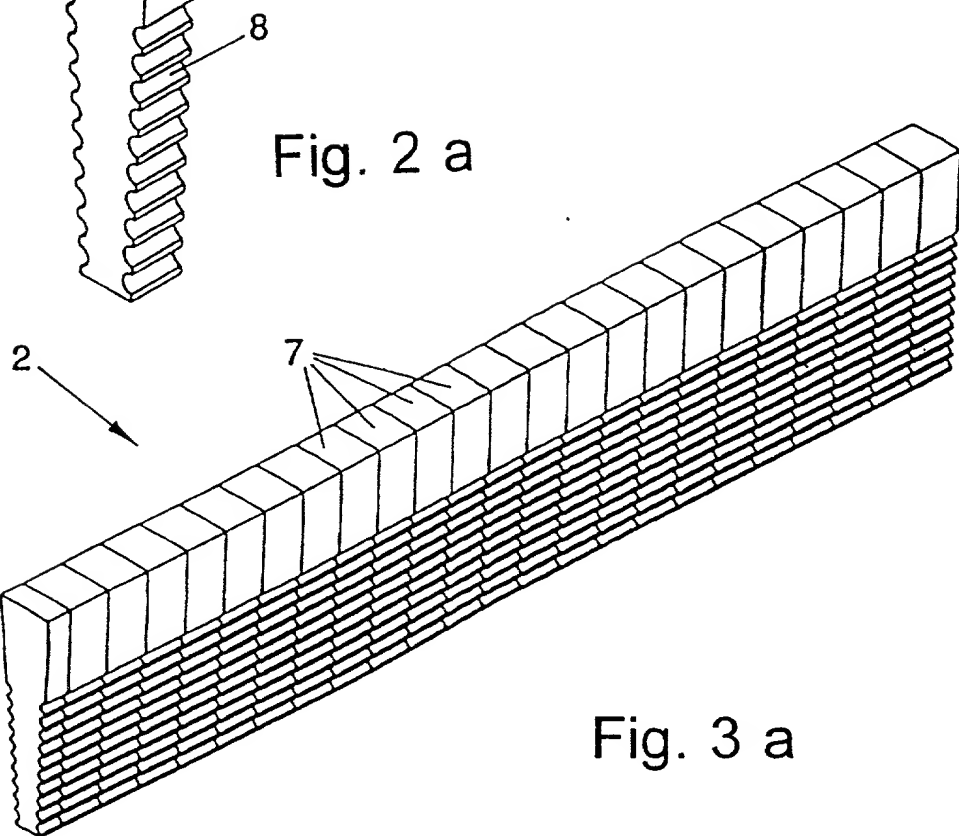


Fig. 2 a

Fig. 3 a

2/6

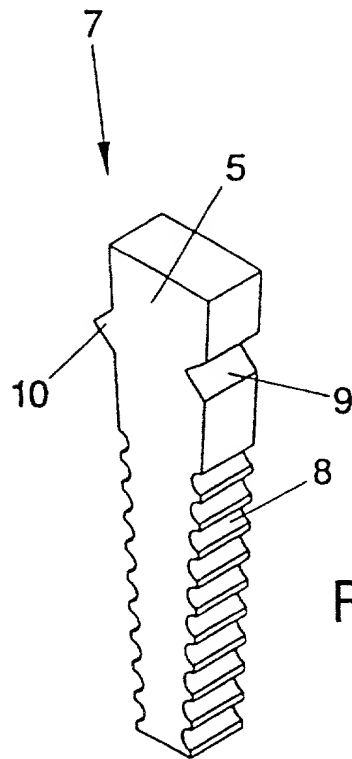


Fig. 2 b

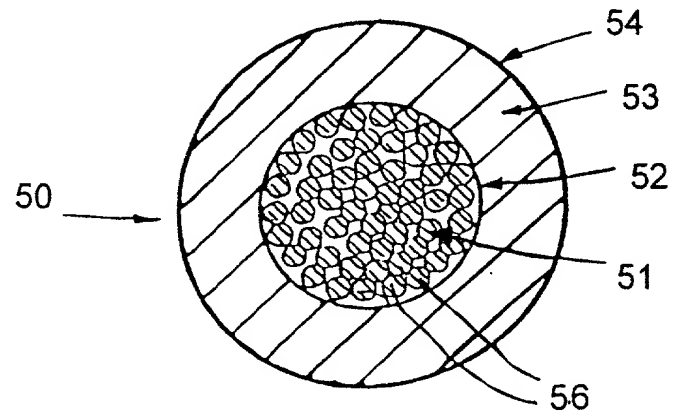


Fig. 10

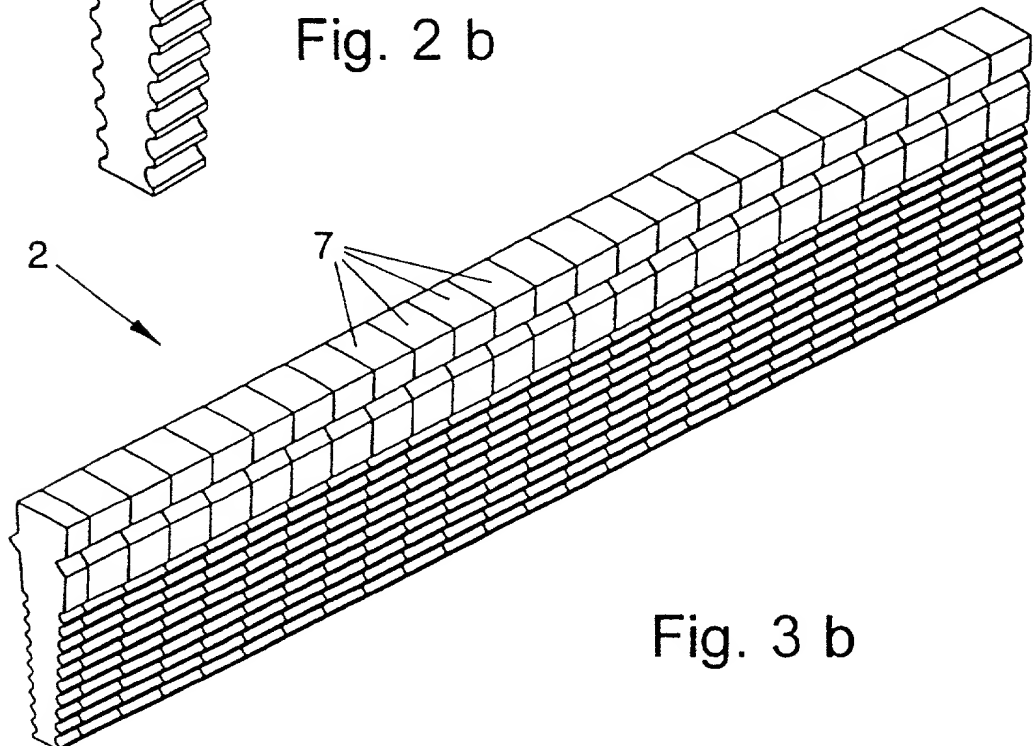
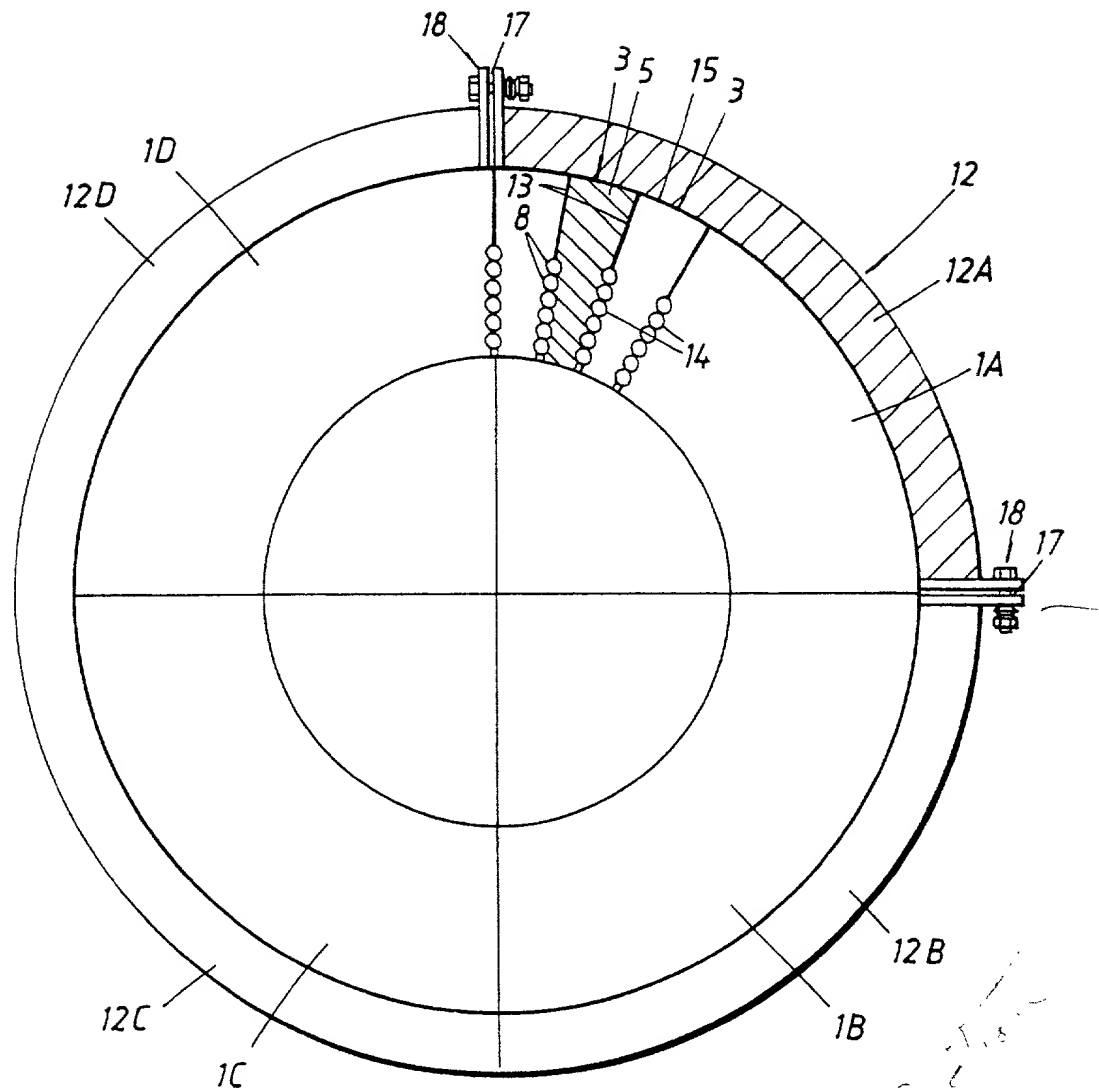


Fig. 3 b

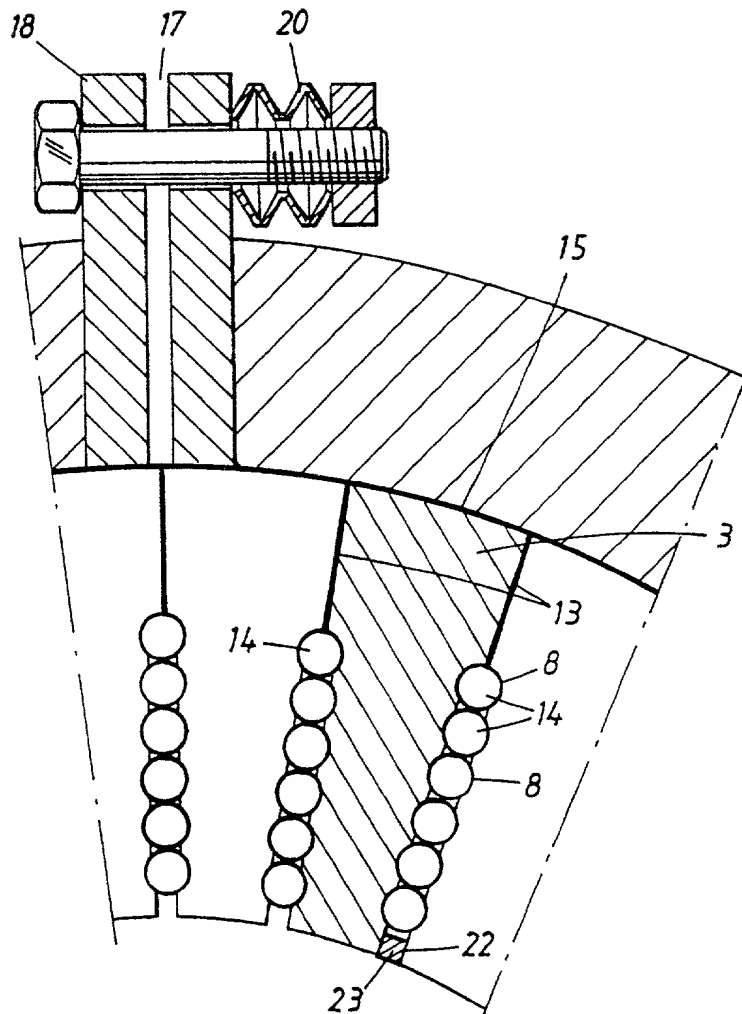
3/6

Fig. 4



4 / 6

Fig. 5



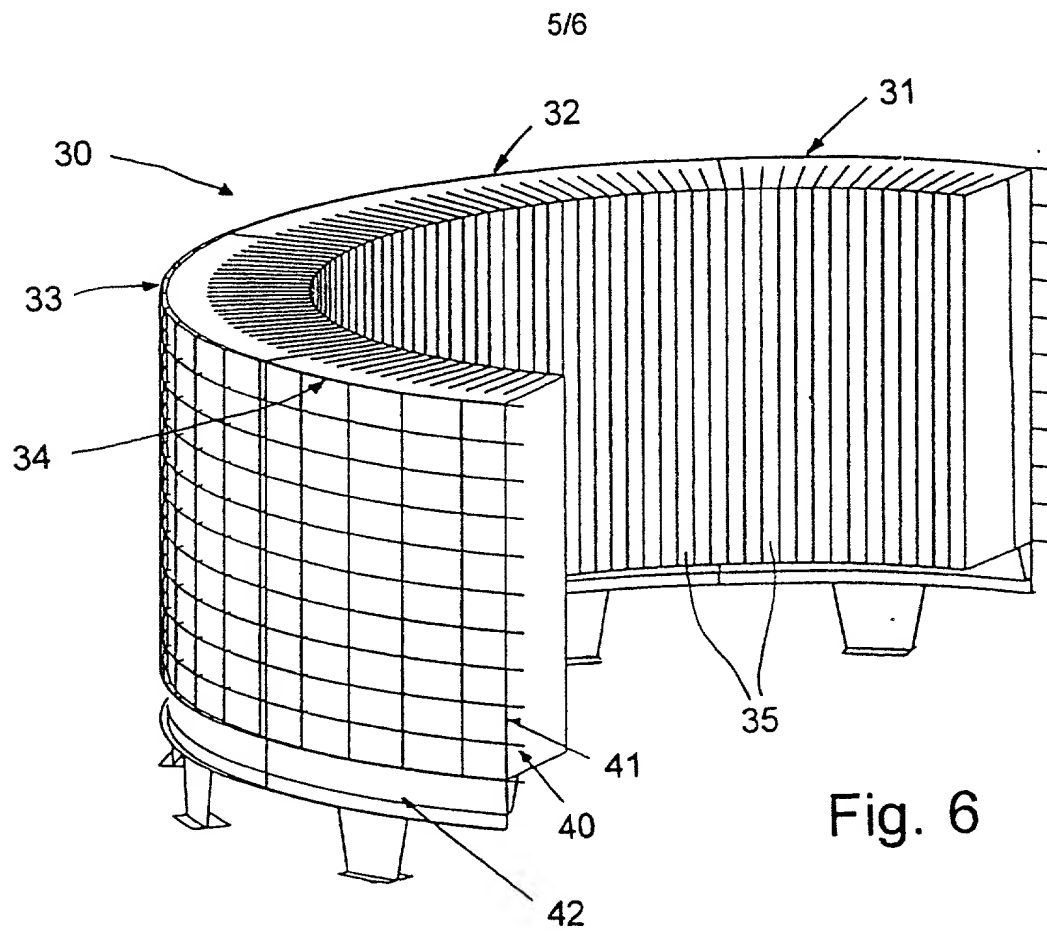


Fig. 6

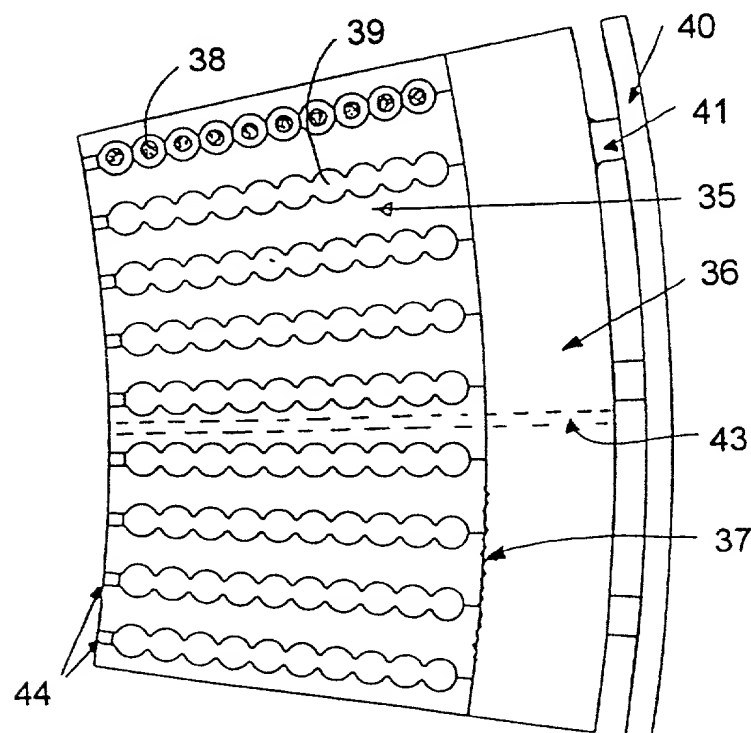


Fig. 7

6/6

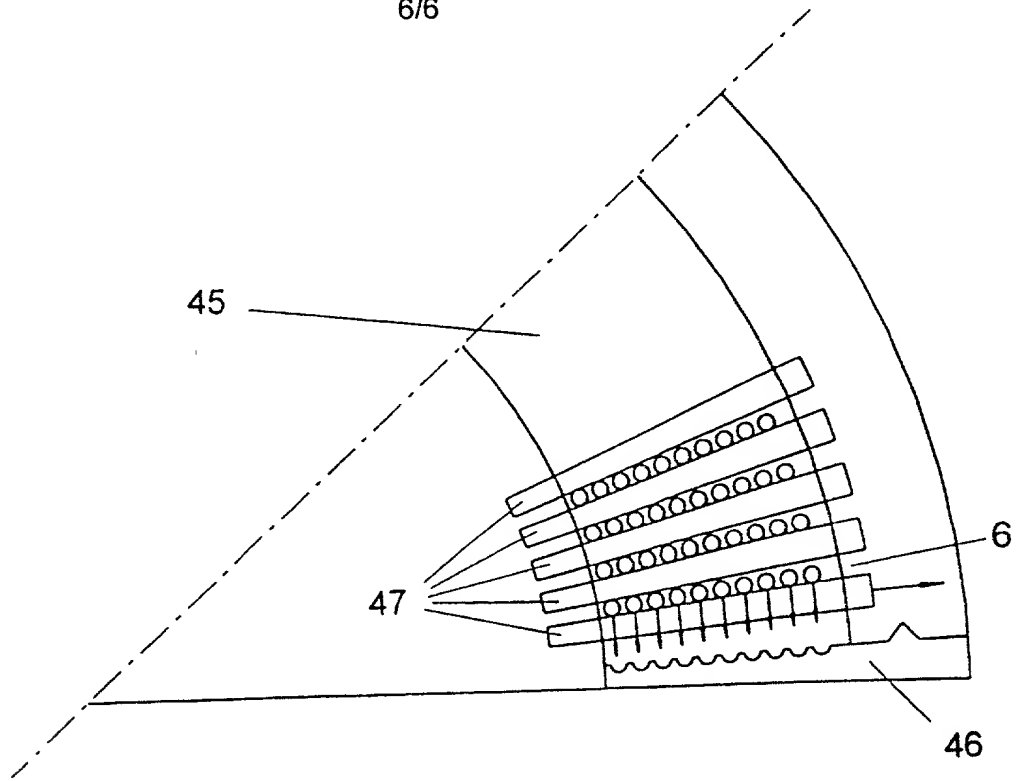


Fig. 8

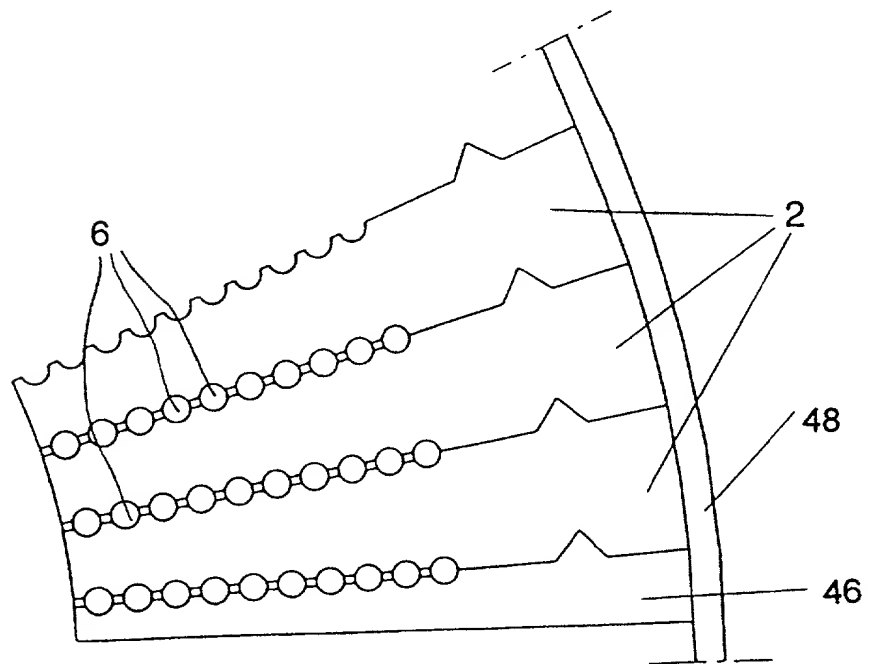


Fig. 9

8-28345

COMBINED DECLARATION AND POWER OF ATTORNEY
FOR UTILITY PATENT APPLICATION (Includes PCT)

Attorney Docket No.
705/71862-2/8083

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; that

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

A STATOR FOR A ROTATING ELECTRIC MACHINE AND A METHOD OF MANUFACTURING A STATOR

the specification of which (check one): ☐ is attached hereto.

☐ was filed on _____ as Application Serial No. _____ and was amended on _____.

☒ was filed as PCT international application no. PCT/SE97/01840 on November 4, 1997, and was amended under PCT Article 19 on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I do not know and do not believe the claimed invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application.

I hereby claim foreign priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application(s) on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

<u>9604026-6</u> (Number)	<u>Sweden</u> (Country)	<u>4 November 1996</u> Day/Month/Year Filed	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
<u>9703718-8</u> (Number)	<u>Sweden</u> (Country)	<u>13 October 1997</u> Day/Month/Year Filed	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
_____ (Number)	_____ (Country)	_____ Day/Month/Year Filed	<input type="checkbox"/> Yes	<input type="checkbox"/> No

I hereby claim the benefit under Title 35, United States Code, §119 (e) of any United States provisional application(s) listed below:

_____ Application No.	_____ Day/Month/Year Filed	_____ Application No.	_____ Day/Month/Year Filed
--------------------------	-------------------------------	--------------------------	-------------------------------

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

9

Application Serial No.

Filing Date

Status (patented, pending, abandoned)

Application Serial No.


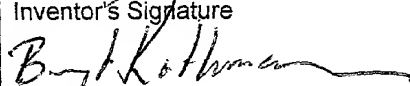
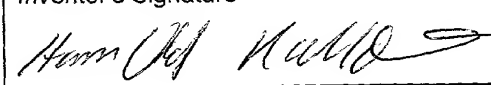
Filing Date

Status (patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith; Watson Cole Grindle Watson, P.L.L.C.; Lawrence R. Radanovic, Reg. No. 23,077; Richard H. Tushin, Reg. No. 27,297; Donald N. Huff, Reg. No. 27,561; John P. DeLuca, Reg. No. 25,505; Walter D. Ames, Reg. No. 17,913 and Roy W. Butrum, Reg. No. 18,290. Direct all telephone calls to telephone no. (202) 628-3600 and faxes to (202) 628-3650.

Address all correspondence to Watson Cole Grindle Watson, P.L.L.C., 10th Floor, 1400 K Street, N.W., Washington, D.C. 20005-2477.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole, First Inventor <u>Bertil LARSSON</u>	Inventor's Signature 	Date May 21, 1999
Residence: <u>Sammetsvagen 12, S-724 76 Vasteras, SWEDEN</u> SEX		Citizenship Swedish
Post Office Address: SAME		
Full Name of Second, Joint Inventor <u>Bengt ROTHMAN</u>	Inventor's Signature 	Date May 21, 1999
Residence: <u>Profilgatan 16, S-723 36, Vasteras, SWEDEN</u> SEX		Citizenship Swedish
Post Office Address: SAME		
Full Name of Third, Joint Inventor <u>Hans-Olof KALLDIN</u>	Inventor's Signature 	Date May 27, 1999
Residence: <u>Grenadjargatan 9, S-723 46, Vasteras, SWEDEN</u> SEX		Citizenship Swedish
Post Office Address: SAME		

4-00

Full Name of Fourth, Joint Inventor <u>Mats LEIJON</u>	Inventor's Signature <i>Mats Leijon</i>	Date June 4, 1999
Residence: Hyvlargatan 5, S-723 35, <u>Vasteras</u> , SWEDEN SEX		Citizenship Swedish
Post Office Address: SAME		
Full Name of Fifth, Joint Inventor <u>Soren BERGGREN</u>	Inventor's Signature <i>Soren Berggren</i>	Date May 21, 1999
Residence: Vetterstorgsgatan 30, S-724 62, <u>Vasteras</u> , SWEDEN SEX		Citizenship Swedish
Post Office Address: SAME		
Full Name of Sixth, Joint Inventor	Inventor's Signature	Date
Residence:		Citizenship
Post Office Address:		
Full Name of Seventh, Joint Inventor	Inventor's Signature	Date
Residence:		Citizenship
Post Office Address:		

5-00